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STANDARDIZED TESTING CAPABILITIES AT U.S. NAVY TRANSDUCER REPAIR FACILITIES

NAVAL SHIP SYSTEMS COMMAND
DEPARTMENT OF THE NAVY
WASHINGTON, D.C. 20360

AUGUST 1972

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~~...WITHOUT THE PERMISSION OF THE COMMANDER NAVAL SHIP SYSTEMS COMMAND~~

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Section 1. GENERAL INFORMATION

1.1 SCOPE AND RATIONALE. This publication, prepared for Naval Ship Systems Command PMS 302-7, describes the standardized testing capabilities of the Navy's three Transducer Repair Facilities (TRFs), located at the Boston, Mare Island, and Pearl Harbor Naval Shipyards. The capabilities covered are those existing or nearing readiness as of August 1972, and relate to acceptance tests done at the TRFs on new or restored transducers/hydrophones. The tests normally consist of acoustical performance tests, hydrostatic pressure tests, and electrical insulation integrity tests. The absence in this publication of any testing capability does not mean that that capability does not exist at any or all of the TRFs--it merely means that this capability is not standardized at all three TRFs. As more TRF testing capabilities are standardized, appropriate sections will be added to this publication. The intent is to describe TRF testing capabilities in sufficient detail to enable the writer of a restoration and repair manual to determine whether a desired test can be made, and to what accuracy. Thus, it supplements NAVSHIPS 0967-412-7050, "Preparation Format for Sonar Equipment Restoration and Repair Manuals". It is not the intent of this publication to describe every feature of every instrument nor to provide enough detail to enable one to write a step-by-step test procedure or describe exact system hook-up. Nevertheless, it should provide the information on testing capabilities generally needed by transducer manufacturers and cognizant project/program managers.

Section 2. UNDERWATER ACOUSTICAL TEST CAPABILITIES

2.1 GENERAL. The Sonar Test Set AN/FQM-10(V) represents the primary capability at the TRFs for testing the acoustical and electrical characteristics of transducers and hydrophones while immersed in water, operating in their normal modes and at normal power levels. These tests are the usual criteria for accepting or rejecting new or repaired units. Transducers and hydrophones whose values test within the range of established test tolerances for each parameter are then shipped to an installing shipyard or placed in the Navy Supply System with a ready-for-issue designation. Units failing these tests are returned for remanufacture, repair, salvage or disposal as appropriate.

2.2 MEASUREMENT CAPABILITIES OF THE SONAR TEST SET AN/FQM-10(V). The following acoustical and electrical tests can be performed at the TRFs by the use of an AN/FQM-10(V) Sonar Test Set:

a. Low level impedance/admittance measurements (continuous transmission)
b. High level impedance/admittance measurements (pulsed or continuous transmission)
c. Parameters measured and plotted versus frequency
   1. Free-field voltage sensitivity
   2. Transmitting voltage response
   3. Transmitting current response
   4. Impedance/admittance
d. Source levels (single element or stave)
e. Directivity patterns
f. Reciprocity calibration
g. Insulation resistance
h. dc resistance

i. Capacitance and dissipation factor

j. Null balance measurements

k. Harmonic distortion

2.3 CHARACTERISTICS OF THE SONAR TEST SET AN/FQM-10(V). The following specifications are applicable to the overall system. Individual instruments generally exceed these specifications by considerable margins. Paragraphs 2.4 through 2.7 describe AN/FQM-10(V) functional subsystems in more detail.

2.3.1 <u>Overall System Characteristics</u>

Frequency Range:	50 Hz to 500 kHz (low power) 200 Hz to 15 kHz (high power)*
Operating Modes:	Pulsed or continuous transmission
Dynamic Range:	50 dB
Linearity:	±0.5 dB over 50 dB range
Frequency Response:	±0.5 dB per decade of range

2.3.2 <u>Transmit/Power Amplifier Characteristics</u>

2.3.2.1 Pulse Generation

Pulse Repetition Frequency:	0.1 Hz to 300 Hz
Transmit Pulse Width:	10 μsec to 1.1 sec

2.3.2.2 Low Power Amplifiers (2)

Output Rating:	50 VA, single unit 100 VA, 2 units in cascade
Frequency Range:	50 Hz to 500 kHz
Output Impedance:	2, 8, 32, 128 Ω (single amplifier) 4, 16, 64, 256 Ω (cascade configuration)
Distortion:	0.3% maximum

*High power amplifiers may be used from 15 kHz to 60 kHz at reduced power levels with a maximum duty cycle of 10%.

2.3.2.3 High Power Amplifiers (3)

Power Output:	3 kVA per amplifier at any load power factor from zero leading or lagging to unity. Up to 3 amplifiers may be connected in parallel to give a maximum power output capability of 9 kVA
Frequency Range:	200 to 15,000 Hz at full power continuous duty 15 kHz to 60 kHz at reduced* power, pulsed duty
Output Impedance:	4, 16, 32, 64, 144, and 576 Ω (single amplifier; parallel operation results in reduced impedance)
Distortion:	Less than 2% into a resistive load, 200 Hz to 15 kHz

2.3.2.4 Power Amplifier Control

Control Modes:	Drive voltage or current maintained at a constant preset level adjustable over a 50 dB dynamic range
Regulation:	0.25 dB, 200 Hz to 500 kHz 0.75 dB, 50 Hz to 200 Hz
Preselection Range:	0.1 to 150 V rms low power 10 to 1320 V rms high power 0.01 to 15 A rms low power 0.02 to 30 A rms high power

2.3.2.5 High Level Impedance/Admittance Measurements

Frequency Range:	100 Hz to 500 kHz
Accuracy (100 Hz to 200 kHz):	Vector amplitude, ±1% of full scale ±1% of reading Phase ±2° Voltage or current amplitude, ±1% of full scale ±1% of reading

*High power amplifiers may be used from 15 kHz to 60 kHz at reduced power levels with a maximum duty cycle of 10%

Accuracy (200 kHz to 500 kHz):	Vector amplitude, ±1% of full scale ±3% of reading Phase ±4° Voltage or current amplitude, ±1% of full scale ±3% of reading
Voltage Range:	1 to 1320 V rms
Current Range:	100 mA to 50 A rms
Impedance Range Full Scale:	10, 100, 1000, 10,000 and 100,000 Ω
Admittance Range Full Scale:	1, 0.1, 0.01, 0.001, and 0.0001 mho
Selectable Output Modes	R ±jX, impedance vector components G ±jB, admittance vector components Z $\underline{/\theta}$, impedance vector magnitude and phase Y $\underline{/\phi}$, admittance vector magnitude and phase
Pulse Repetition Frequency:	100 Hz maximum

2.3.3 <u>Receiving/Recording Characteristics</u>

2.3.3.1	Input Configuration:	Differential or single-ended
	Impedance:	Differential, 200 MΩ shunted by 25 pF Single-ended, 100 MΩ shunted by 50 pF
	Gain:	-20 to +60 dB in 10 dB steps
	Response:	±1 dB
	Wideband Noise (Input Shorted)	15 μV max
2.3.3.2	Signal Detection	
	Receive Gate Delay:	10 μsec to 1.1 sec
	Receive Gate Width:	10 μsec to 5 sec
	Input Voltage Range: (from Preamplifier)	1 dBV to -63.8 dBV with dynamic autoranging
	Measurement Modes:	Peak or rms
	Measurement Scale:	Logarithmic
	Peak Mode Accuracy:	0.25 dB 50 Hz to 500 kHz
	rms Mode Accuracy:	0.25 dB 50 Hz to 100 kHz 0.5 dB 100 kHz to 500 kHz

2.3.3.3 Wave Analyzers

Sweep Frequency Range:	50 Hz to 500 kHz
Bandwidth (50 Hz to 54 kHz):	3, 10, or 50 Hz
Bandwidth (1 kHz to 500 kHz):	200 Hz
Bandwidth (5 kHz to 500 kHz):	1000 Hz
Bandwidth (10 kHz to 15 MHz):	3000 Hz

2.3.3.4 Polar Recorder

Chart Scale:	10 dB/in
Chart Response:	360° synchro controlled
Data Recorded:	Directivity patterns

2.3.3.5 Rectangular Recorder

Chart Scale:	5 dB/in
Chart Response:	For Directivity Patterns 10°, 60°, or 360° per 20 in of paper, synchro controlled For Frequency Responses Logarithmic: 1 or 2 decades per 20 in of paper Linear: 1, 10, or 100 kHz per 20 in of paper
Data Recorded:	Directivity Patterns Frequency Responses

2.3.3.6 X-Y Recorder

Chart Scale:	Adjustable
Chart Response:	Adjustable
Data Recorded:	Frequency responses Impedance/admittance loops Frequency spectrums
Curve Follower:	Used for plotting absolute frequency responses

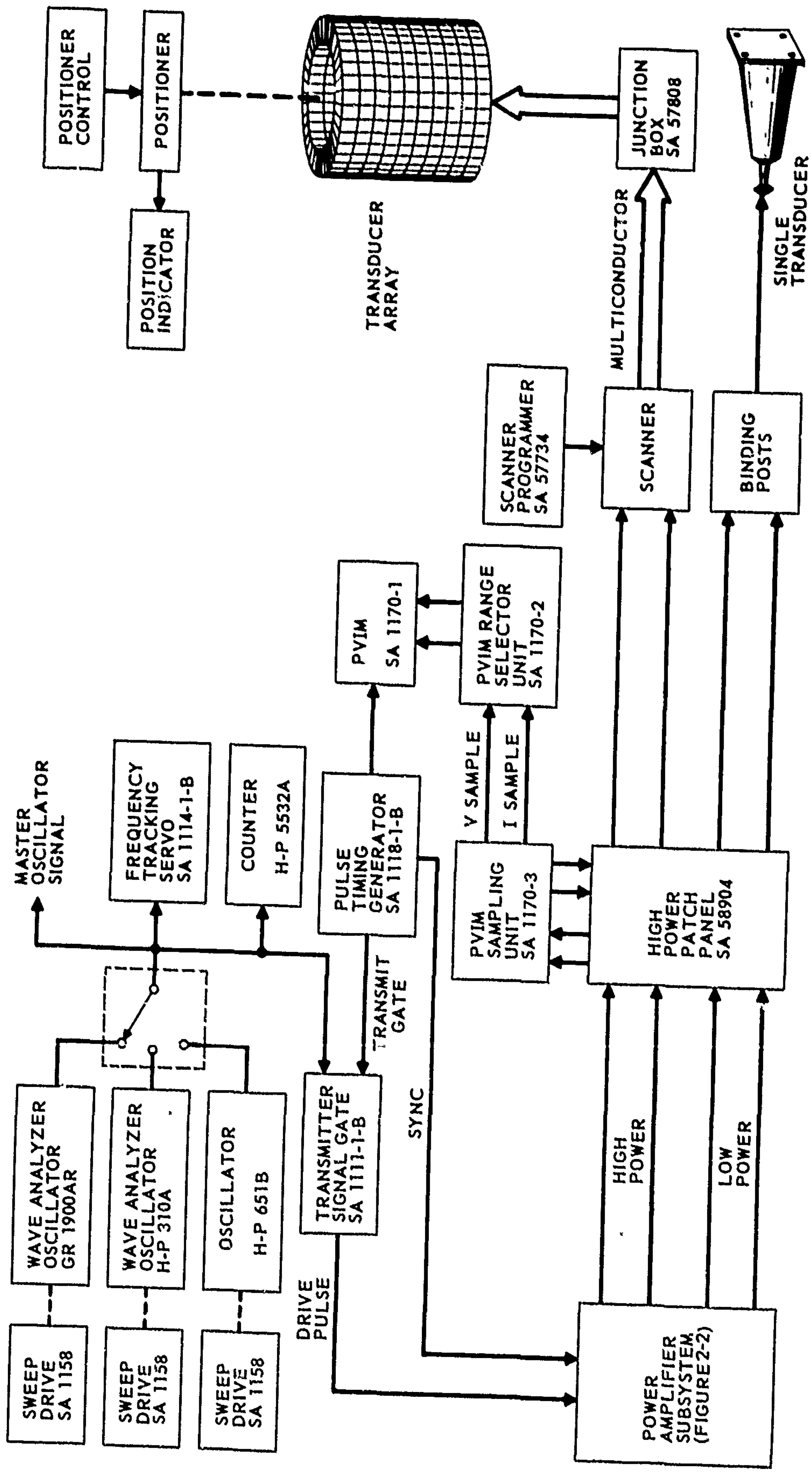

FIGURE 2-1
TRANSMIT SUBSYSTEM SIMPLIFIED BLOCK DIAGRAM
TEST SET, SONAR AN/FQM-10(V)

2.3.4 <u>Waveform Monitoring Capabilities</u>

Oscilloscope:	Dual channel, storage mode, dc to 10 MHz
Recording Camera:	Polaroid camera with mounting bezel

2.3.5 <u>Ancillary Capabilities</u>

Insulation Resistance	
Test Voltages:	100 and 500 Vdc
Ranges:	0.5 to 2,000,000 MΩ
dc Resistance	
Range:	0.1 Ω to 5000 MΩ
Universal Bridge	
Capacitance Range:	1 nF to 100 μF with ±1% accuracy 1 pF to 1000 μF with ±2% accuracy
Dissipation Factor:	Series C, 0.001 to 0.12 Parallel C, 0.05 to 50 Accuracy ±5%
Low Level Impedance-Admittance Measurements	
Parameters Measured:	Vector impedance, vector admittance, capacitance, inductance
Frequency Range:	100 Hz to 200 kHz with no nulling required
Outputs:	dc analog signals useful for plotting continuous locus curves

2.4 FUNCTIONAL DESCRIPTION OF THE TRANSMIT SUBSYSTEM. A simplified block diagram of the Transmit Subsystem is shown in Fig 2-1. Its main functional parts are grouped as follows: the master oscillators, the frequency tracking servo, the transmitter signal gate/pulse timing circuits, the power distribution circuits, the Pulsed Vector Immittance Meter (PVIM) and associated devices and, finally, the transducer positioners.

2.4.1 <u>Master Oscillator Signals</u>. Three system oscillators generate either fixed or swept sinusoidal signals over the frequency range of 50 Hz to 500 kHz, one of which may be selected for providing the best

coverage of the frequency range of interest. Sweep drives are mechanically coupled to each of the oscillators to provide a wide range of linear or logarithmic sweep speeds. A frequency counter is provided to monitor the frequency of the master oscillator signal selected.

2.4.2 Frequency Tracking Servo. The master oscillator signal is fed into a closed loop servo repeater that produces a linear or logarithmic synchro transmitter rotation proportional to the frequency at the input. The synchro output is then used to drive a rectangular recorder used to record frequency response data. An analog output proportional to frequency is also provided.

2.4.3 Transmit Gating/Timing. A pulse timing generator provides the synchronization pulses required to operate system gates and detectors. Controls are provided to adjust the pulse repetition rate and the transmitter gate width. The unit can be synchronized to the system oscillator, causing the transmitter signal gate to pass an integral number of cycles per pulse. The output of the transmitter signal gate then supplies the sinusoidal drive pulse or continuous signal to the Power Amplifier Subsystem.

2.4.4 Power Distribution. The output of either the high power or low power amplifier is selected at the high power patch panel and patched to either the binding posts used to attach a single transducer or to the scanner, which is used to connect a given element of a 432-element array or a given stave of a 48-stave array. The scanner programmer is used to select the element and/or stave to be tested. The junction box allows leads from 432-element transducers or 48-stave transducers to be easily connected to the system for testing.

2.4.5 Pulsed Vector Immittance Meter. The Pulsed Vector Immittance Meter (PVIM) measures the driving-point impedance or admittance (immittance) of a transducer driven by a pulsed or continuous sinusoidal signal. The PVIM sampling unit, located at the terminals of the transducer under test,

samples and scales the drive voltage and current waveforms. The PVIM range selector unit determines the amplitude scaling of the waveform samples and must be manually controlled to keep the normalized input to the PVIM within a ±3 dB range. During admittance tests the drive current is held constant and the sampled voltage must be normalized. For impedance measurements the drive voltage is held constant and the current sample normalized. Two digital readouts can be used to display either measured impedance vectors, impedance magnitude and phase, the admittance vectors, or the admittance magnitude and phase. Analog dc outputs are also provided for use with the X-Y recorder in plotting complex immittance versus frequency plots or vector immittance locus plots.

An alternate use of the PVIM is for measuring rms values of transducer driving voltage or currents. Voltage or current is displayed in the digital readout normally used to display immittance magnitude.

2.4.6 Transducer Positioners. The rotation and depth of the transducer under test are controlled by an electromechanical positioning system. Positioners used by the TRFs are not a standard part of the AN/FQM-10(V) Sonar Test Set and will vary physically at different locations.

2.5 FUNCTIONAL DESCRIPTION OF THE POWER AMPLIFIER SUBSYSTEM. The Power Amplifier Subsystem consists of two groups of amplifiers, a low power group and a high power group, to cover the frequency and power ranges needed. Figure 2-2 shows a simplified block diagram of this subsystem.

2.5.1 Low Power Amplifiers. The low power amplifier group consists of two wideband, low distortion power amplifiers that provide driving power over the systems frequency range of 50 Hz to 500 kHz. The outputs of the two parallel driven amplifiers are connected to two matching transformers which provide both isolation and a wide range of output impedances. When a single amplifier is selected, the maximum output is 50 VA at

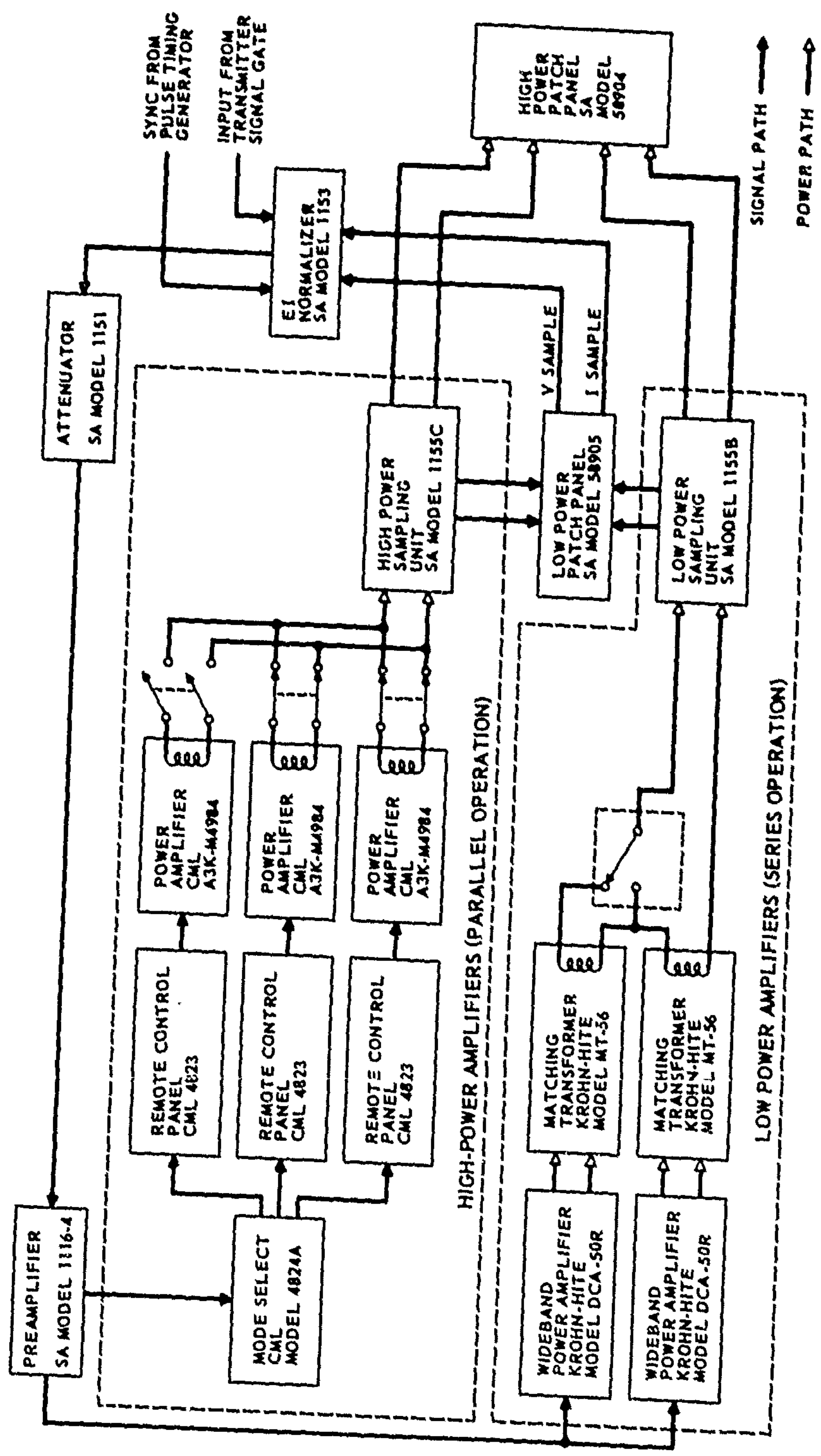

FIGURE 2-2
POWER AMPLIFIER SUBSYSTEM SIMPLIFIED BLOCK DIAGRAM
TEST SET, SONAR AN/FQM-10(V)

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switchable impedances of 2, 8, 32, or 128 Ω. With the two outputs connected in series, 100 VA of power is available but with output impedances of 4, 16, 64, or 256 Ω.

2.5.2 High Power Amplifiers. The high power amplifier group is also shown in Fig 2-2. The system contains three power amplifiers that give a maximum power output capability of 9 kVA when connected in parallel. Each amplifier is rated at 3 kVA continuous duty at any load power factor from zero leading or lagging to unity, over a frequency range of 200 Hz to 15 kHz. Each of the three power amplifiers is remotely controllable from the main AN/FQM-10(V) console. The output transformer taps of each amplifier are selectable to match loads of 4, 16, 32, 64, 144, or 576 Ω. Tap selection is accomplished by means of interchangeable plug-in connectors. For parallel operation of the amplifiers each unit must be set for the same impedance tap. The true output impedance is the selected tap, divided by the number of amplifiers in use. Thus, for the maximum output of 9 kVA, effective taps are 1.3, 5.3, 10.7, 21.3, 48, or 192 Ω.

2.5.3 Extended Frequency Range Operation. Over the frequency range 15 kHz to 60 kHz the high power amplifiers may be used at reduced power levels with a maximum duty cycle of 10%. Figure 2-3 displays the maximum safe

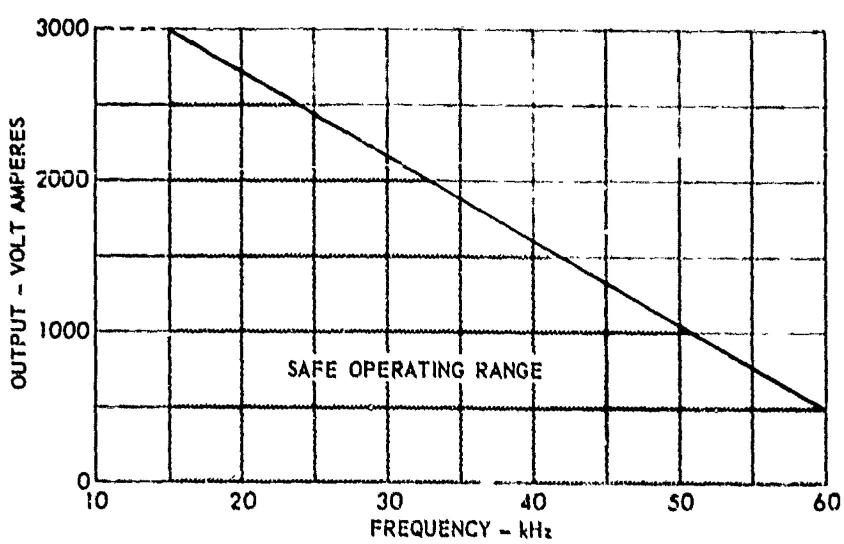


FIGURE 2-3
MAXIMUM SAFE OUTPUT OF CML MODEL A3K
POWER AMPLIFIER FROM 15 – 60 kHz

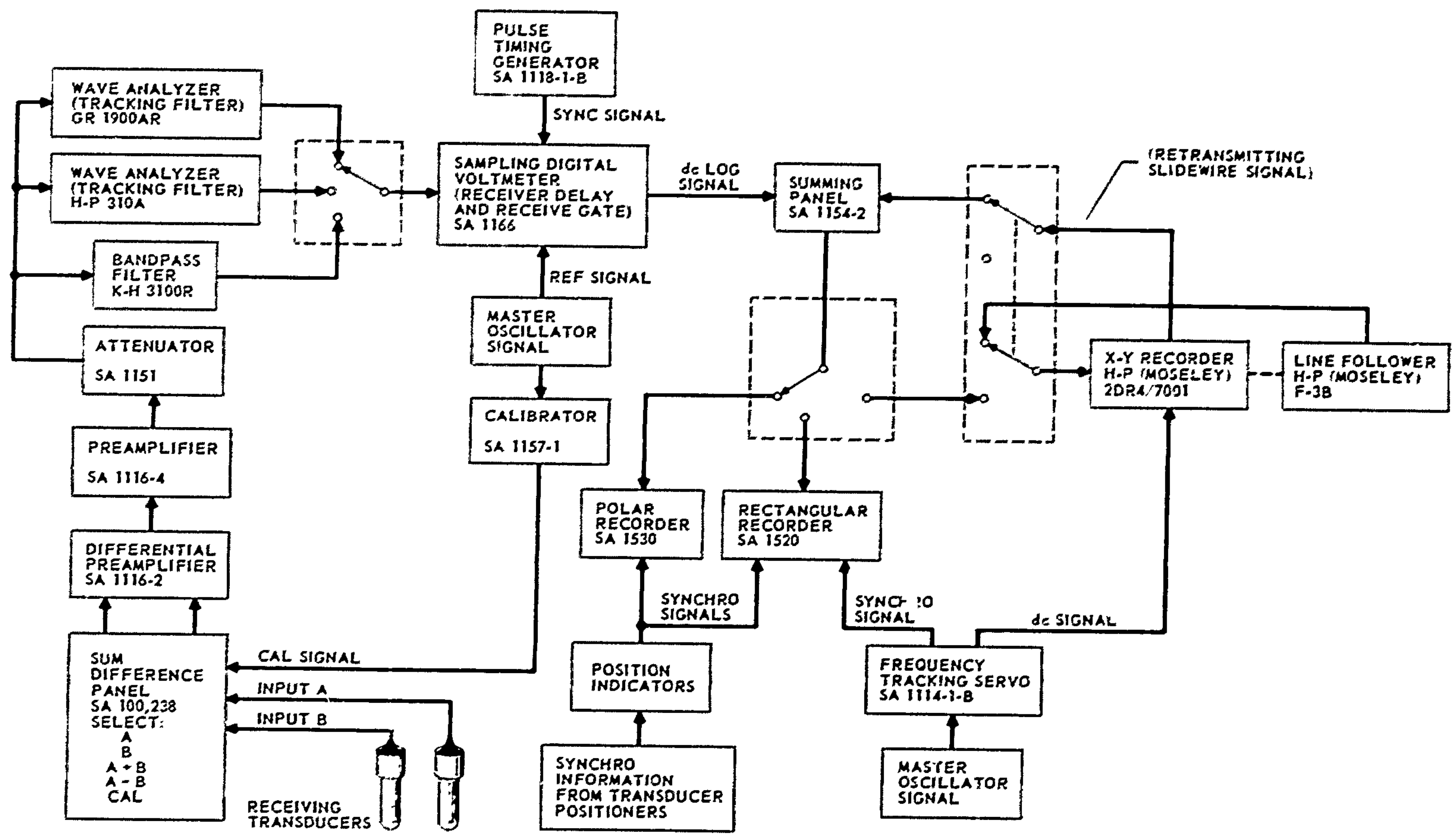


FIGURE 2-4
RECEIVING/RECORDING SUBSYSTEMS SIMPLIFIED BLOCK DIAGRAM
TEST SET, SONAR AN/FQM-10(V)

output of a single high power amplifier at these higher frequencies. No paralleling of units is permissible in the extended frequency range.

2.5.4 Power Amplifier Control. The EI normalizer is a closed loop servo system used to maintain the output voltage or current of the high or low power amplifier at a constant preselected level. It fits into the subsystem as shown in Fig 2-2. A switch located at the preamplifier is used to select either high or low power operation. The corresponding sampling unit is patched into the input of the EI normalizer where either the voltage or current sample is detected and summed with a fixed reference voltage. The resultant error voltage positions a log potentiometer, which attenuates the signal from the transmitter signal gate before it is preamplified and applied to the input of the selected power amplifier group. The normalized outputs to the power amplifiers are available for external use at the high power patch panel.

2.6 FUNCTIONAL DESCRIPTION OF THE RECEIVING SUBSYSTEM. The Receiving Subsystem can be considered in four parts: input, signal amplification, filtering/distortion analysis, and detection. Figure 2-4 shows a simplified block diagram of the Receiving Subsystem.

2.6.1 Input Configuration. Both single-ended and differential inputs are provided for two transducers. At the sum-difference panel the signals at the terminals of these two transducers may be selected separately, added, or subtracted before amplification. A separate continuous cw calibration signal may also be selected.

2.6.2 Signal Amplification. A low noise differential preamplifier with selectable gains from -20 dB to +60 dB in 10 dB steps is used to amplify the input signals. A second preamplifier with 20 dB or 40 dB of additional gain is also provided.

2.6.3 Filtering/Distortion Analysis. Prior to detection, the preamplified signal can be filtered to reject unwanted signals outside of a selected passband. Harmonic distortion in the acoustic output of a transducer can be measured by using the tracking filters of either of two wave analyzers.

2.6.4 Detection. The rms value of the amplified signal is measured by using the sampling digital voltmeter. Logarithmic measurements (in decibels) can be made over a dynamic range from -63.8 to 0.0 dBV with dynamic autoranging. Selectable sample delays, gate widths, and cw sample rates are generated internally by this device. A decimal readout with selectable offset capability allows the operator to display such parameters as free-field voltage sensitivity or transmitting response directly. In addition a dc analog recorder output is available.

2.7 RECORDING SUBSYSTEM. The Recording Subsystem is shown by Fig 2-4 also. Both directivity patterns and frequency characteristics are recorded.

2.7.1 Directivity Pattern Recordings. For receive mode beam patterns the receiving transducer is mounted on a positioner and rotated in the incident acoustic field. The recorder chart is driven by a synchro system in the positioner while the detected output of the Receive Subsystem drives the pen. The polar recorder is desirable for recording broad beam patterns because of the direct presentation of sensitivity versus angle. The rectangular recorder is advantageous where narrow beams are recorded because the angular scale can be expanded. Transmit directivity patterns require only that the projecting transducer be rotated as the resulting acoustic field is measured by a fixed hydrophone.

2.7.2 Recordings of Characteristics Versus Frequency. Two recorders, the rectangular recorder and the X-Y recorder, are used to record the sensitivity of a transducer as a function of frequency. For frequency response recordings, the chart drive signal is received from the frequency

tracking servo which converts frequency into both a synchro rotation and a dc analog signal, linearly or logarithmically proportional to the master oscillator's frequency. The rectangular recorder is positioned by a synchro-driver servo while the X-Y recorder follows the dc analog signal. The X-Y recorder is equipped with an optical line follower and a summing panel. This gives the capability of plotting the absolute frequency response of an unknown transducer, provided calibration data is available for the standard hydrophone or projector. Standard parameters plotted versus frequency include free field voltage sensitivity, transmitting voltage response, and transmitting current response.

2.8 ANCILLARY MEASUREMENT EQUIPMENT. The Sonar Test Set AN/FQM-10(V) provides ancillary instrumentation to measure the following parameters: insulation resistance, dc resistance, capacitance, dissipation factor, and low level impedance-admittance.

2.8.1 Insulation Resistance. Each system is supplied with a megohmmeter for the purpose of measuring insulation resistance of transducers. The measurement range of the instrument is from 0.5 to 2,000,000 MΩ. The voltage applied to the unknown is either 100 or 500 Vdc, as selected by a switch on the front panel.

2.8.2 dc Resistance. A wide range, multipurpose dc vacuum tube voltmeter is used to make dc voltage, current, and resistance measurements normally encountered in transducer testing. The resistance measurement capability of the instrument ranges from 0.1 Ω to 5000 MΩ.

2.8.3 Capacitance and Dissipation Factor. A Universal Bridge is used to make measurements of resistance, capacitance, inductance, capacitor dissipation factor, or inductance quality factor. For ac measurements, an internal 1 kHz oscillator is normally used. An input is available for using an external oscillator when other measurement frequencies are desired.

2.8.4 <u>Low Level Immittance</u>. A low level immittance meter provides direct and accurate measurements of vector impedance, vector admittance, capacitance, and inductance over the frequency range of 100 Hz to 200 kHz. The measured parameters are displayed on panel meters and dc outputs are provided for use with an X-Y recorder for plotting vector immitance locus plots.

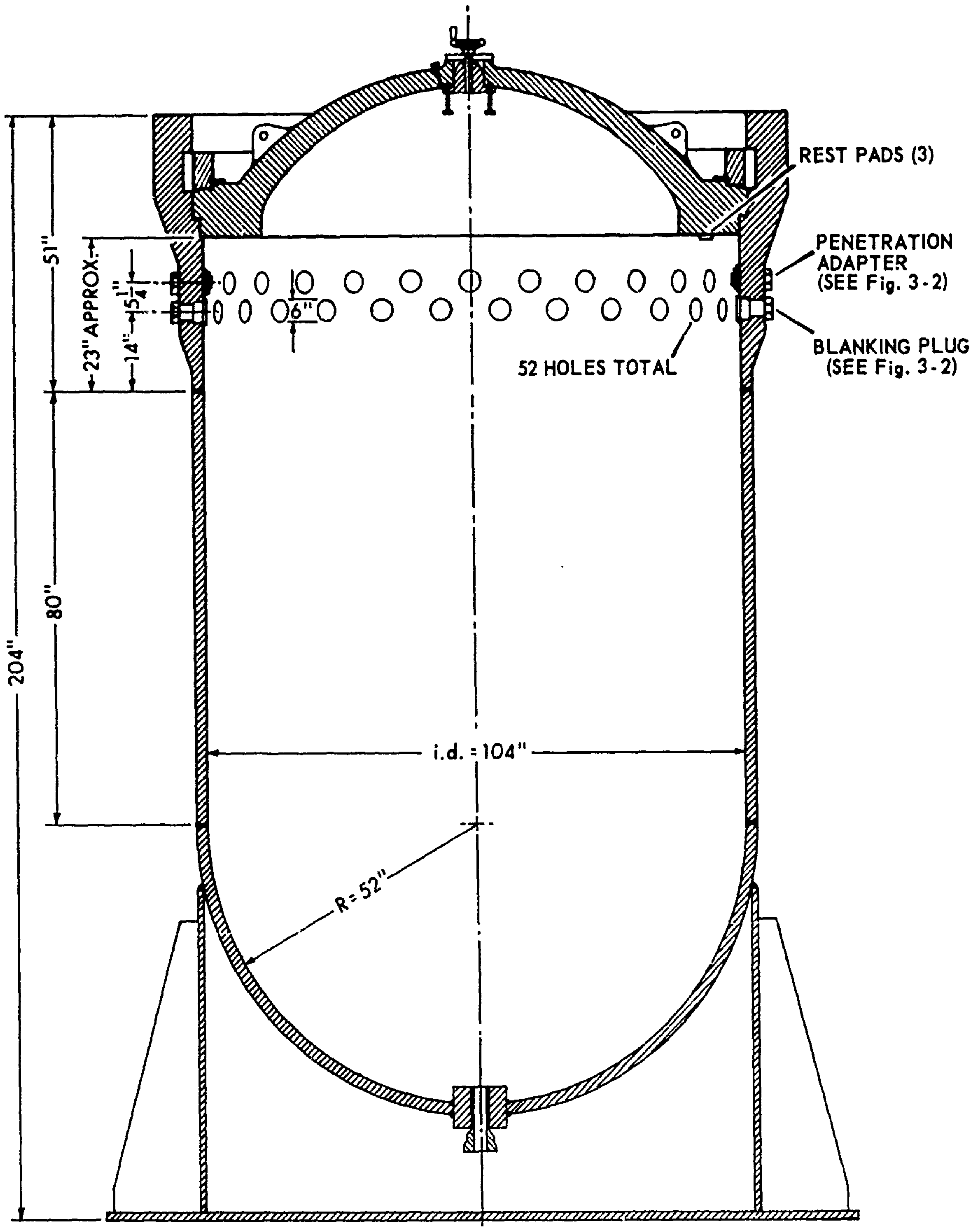


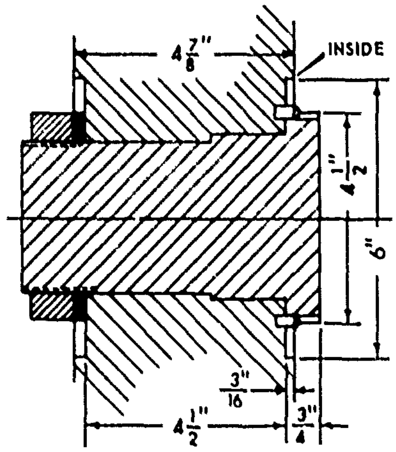
FIGURE 3-1
1000 psi PRESSURE VESSEL

Section 3. PRESSURE TESTING FACILITIES

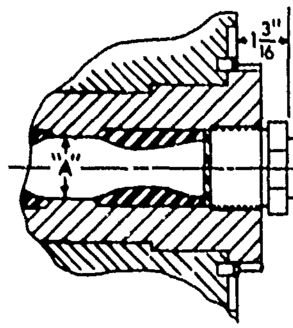
3.1 GENERAL. Each of the three TRFs is equipped with two pressure vessels and associated systems for testing transducers pressurized in fresh water to 1000 psig and 3000 psig respectively. The 1000 psig vessel has a nominal inside diameter of 8 ft 8 in and the 3000 psig vessel, 3 ft. In determining the size of transducers that can be tested in these vessels, allowance must be made for the intrusion of the cable penetrations, blanking plugs, and the proper dress of the cables to the transducer. The system that pressurizes these vessels can be controlled manually, or automatically programmed to cycle the test pressure through any four preselected pressures from 0 psig to the maximum working pressures of the vessels. The programmed timing interval selected for each pressure can be any interval up to 1 h. If desired the program can be made to repeat itself automatically. Provision for rapid filling and draining has been provided. These vessels are located within reach of appropriate weight handling facilities for handling vessel lids and the transducers to be tested.

3.2 1000 psig PRESSURE VESSEL. The configuration of the 1000 psig pressure vessel is depicted in Fig 3-1. The inside diameter is a nominal 8 ft 8 in, but this measurement is reduced by the 52 penetrations (when they are in place) as well as the space needed for cables. The full diameter of the pressure vessel may be utilized throughout a vertical space of 7 ft 6 in, provided the penetrations and/or blanking plugs are dismantled before the transducer is inserted.

3.3 PENETRATIONS. The 52 penetration openings may be equipped with: (1) any of 7 sizes of stuffing tubes, (2) any of 2 sizes of pin connectors,

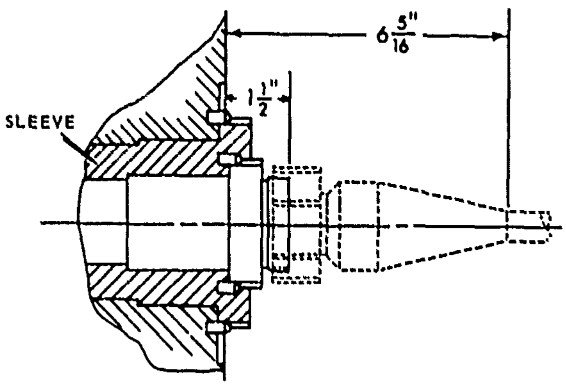


BLANKING PLUG WITH
TYPICAL DIMENSIONS

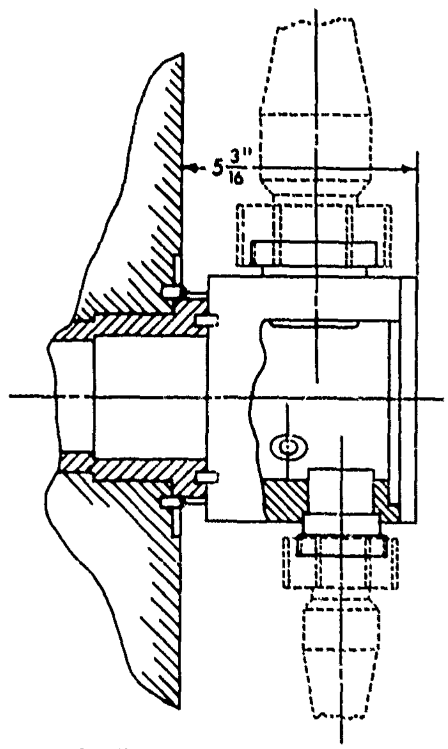


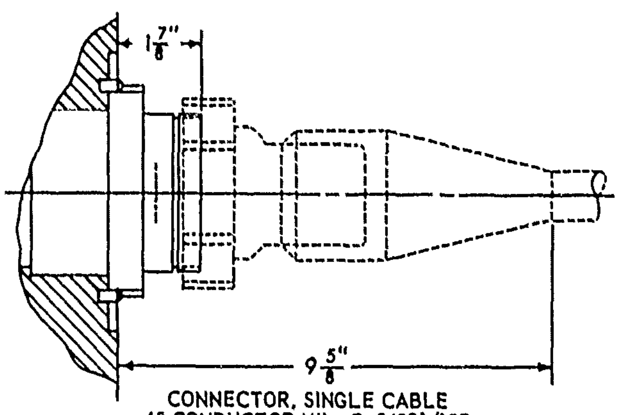
TUBE SIZE	diam A
1	0.609
2	0.812
3	1.062
4	1.265
5	1.437
6	1.625
7	1.875

STUFFING TUBE



CONNECTOR, SINGLE CABLE
7 CONDUCTOR MIL-C-24231/8B





CONNECTOR, SINGLE CABLE
65 CONDUCTOR MIL-C-24231/19B

CONNECTOR, MULTIPLE CABLE
MODIFIED MIL-C-24231/11B WITH
10 EACH MIL-C-24231/12B-3 PIN
OR 10 EACH MIL-C-24231/12B-5 PIN
OR 8 EACH MIL-C-24231/13B 7 PIN
OR 4 EACH MIL-C-24231/27-002-2SWF-4 CABLE

FIGURE 3-2
DETAILS OF PENETRATORS, STUFFING TUBES, AND BLANKING PLUG

(3) any of 4 multiple cable connectors, or (4) a blanking plug to simply seal the opening. Figure 3-2 depicts details of these penetration adapters. The militarized pin connectors are described as follows:

MIL-C-24231/8B	(7 pin connections)
MIL-C-24231/10B	(65 pin connections)
MIL-C-24231/11B	(modified multiple cable connector)
with:	
10 ea MIL-C-24231/12B	(3 pin connections)
or 10 ea MIL-C-24231/12B	(5 pin connections)
or 8 ea MIL-C-24231/13B	(7 pin connections)
or 4 ea MIL-C-24231/27-002	(for 2SWF-4 cable)

The blanking plugs reduce the effective inside diameter by only 1 1/2 in (maximum) when all are in place. Other sizes of stuffing tubes, pin connectors, and multiple cable connectors may be available in the future.

3.4 3000 psi PRESSURE VESSEL. The configuration of the 3000 psi pressure vessel is depicted in Fig 3-3. The inside diameter is a nominal 3 ft, but this dimension is reduced by the penetrators and/or blanking plugs when they are in place and is also reduced by that space required for the cables. The full diameter of the pressure vessel may be utilized throughout a vertical space of 7 ft 5 in provided the penetrators and/or blanking plugs are dismantled before inserting the transducer. Six penetrator openings are built into the vessel. The stuffing tubes, penetration adapters, and blanking plugs are identical to those described in para. 3.3 and used by the 1000 psig pressure vessel.

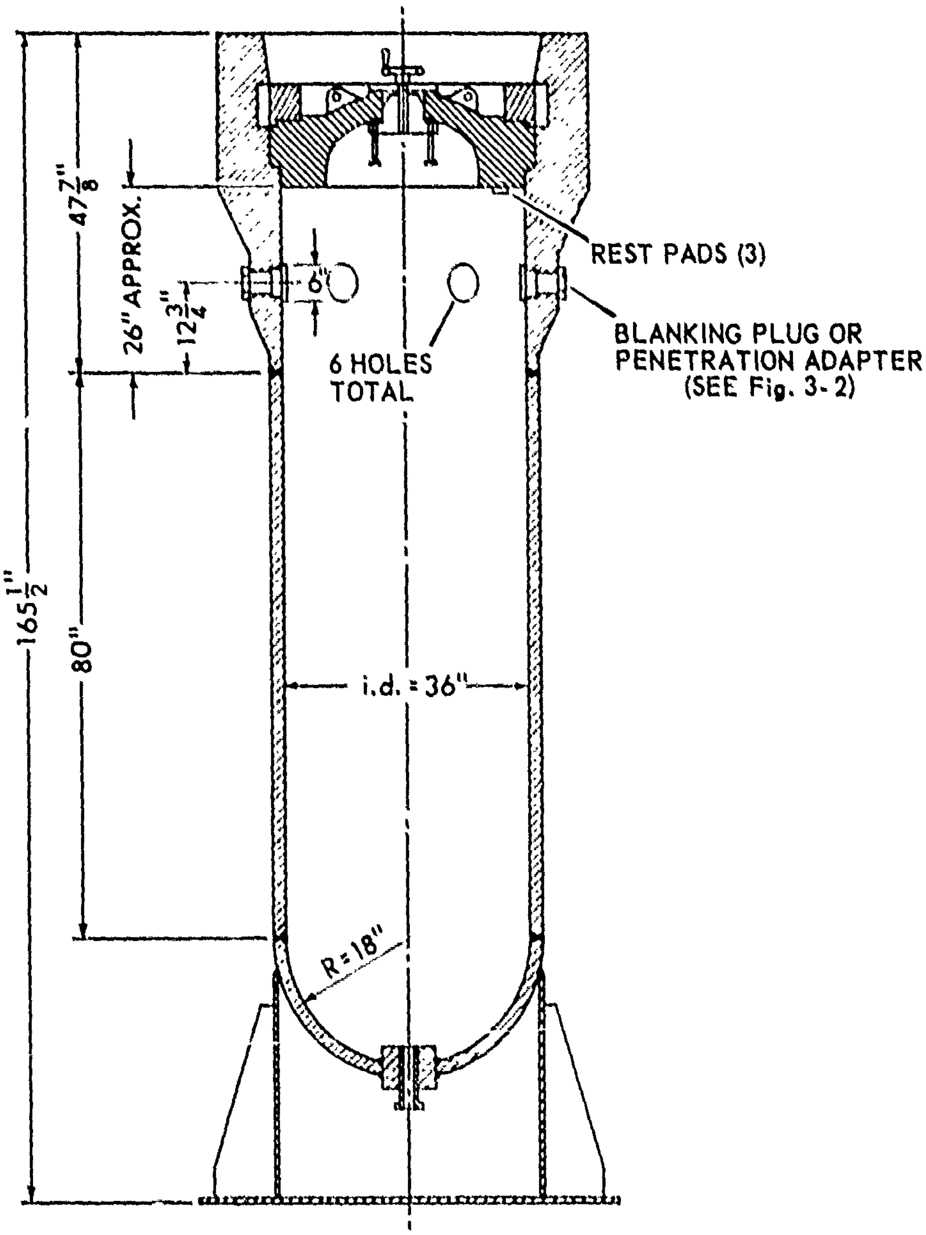


FIGURE 3-3
3000 psi PRESSURE VESSEL

APPENDIX A

CASTOR OIL FILLING SYSTEM FOR SONAR TRANSDUCERS/HYDROPHONES

1. GENERAL. Each of the three TRFs is equipped with standardized systems for filling sonar transducers with DB grade castor oil (FSN 9150-694-1409). Each system has two principal components: the processor which cleans and holds the oil in a reservoir, and the fixture table which properly holds the transducers for filling. Two systems are available at each TRF.

2. PROCESSOR. The processor consists of the equipment and controls necessary to dry and evacuate the oil, store it ready for use, and supply it to the fixture table. All the equipment and controls are installed in a single console connected to the fixture table by hoses.

2.1 <u>Processor Equipment</u>. The processor consists of the following equipment:

a. The reservoir which is a steel tank capable of holding up to 10 gal under vacuum.

b. A thermostatically controlled 1000 W heater which is attached to the outside of the reservoir. The sensor is located in the reservoir and the temperature can be controlled and read on the front of the console.

c. A 100 millitorr, 15 cu ft/min vacuum pump which is coupled to the reservoir by a manually operated valve. A second valve of the same kind enables the pump to be coupled to the fixture table also. These valves are not open at the same time.

d. A gear pump controlled by a selector switch circulates the oil during processing and also supplies it to the fixture table.

2.2 <u>Operation of the Processor</u>. The oil is heated to 125°F to drive off moisture and reduce surface tension. It is then degassed by evacuating

the reservoir. Drying and degassing are improved by circulating the oil slowly over an aerator cone in the top of the reservoir. After drying and degassing are completed, the temperature is reduced to 90°F and the vacuum is reduced to a pressure of 1000 millitorr. The temperature is lowered to prevent thermal shock to the piezoelectric elements of the transducers, and the vacuum is reduced to prevent thickening of the castor oil.

The processor console is equipped with two connections for attaching both the vacuum line and the oil line to the fixture table (or any other similar device that may be required in the future). The vacuum connection is a 1 1/2 in pipe and the oil connection, a 3/8 in pipe. The oil outlet is controlled by a check valve that permits outflow only. When operated in the "fill" mode, the gear pump provides a nominal pressure of 20 to 25 psig; an internal bypass prevents this level from being exceeded.

3. FIXTURE TABLE. The fixture table is a steel workbench modified to support transducers requiring a specified rubber boot or diaphragm shape. It contains transducer mounting fixtures for 5 particular types of transducers. It also provides several filling stations, each of which consists of a transfer tank that is connected to the vacuum line and to the oil fill line, and a hose that attaches it to a transducer for evacuation and subsequent filling.

3.1 Transducer Fixtures. The fixture table provides 13 transducer mounting fixtures of five different types--8 for DT-283 hydrophones, 2 for AT-200 transducers, and 1 each for the AT-186, TR-193, and TR-172/MX6647. The empty transducer is placed in the appropriate fixture. By means of applying external vacuum to the fixture, the transducer's rubber face or boot is distended to conform to the shape of the fixture. Thus the fixture forms and holds in place the rubber boot or diaphragm of the transducer while it is being filled with oil. Each of the 13 fixtures is equipped with its own vacuum line, vacuum

control, and relief valve. It is anticipated that different types of mounting fixtures will replace some of the existing mounting fixtures or be added to the table with the introduction of new types of transducers or hydrophones. The exact mechanisms which will join the new fixtures to the work table will be determined when their installation becomes necessary.

3.2 <u>Transducer Filling Stations</u>. Eight filling stations are available on the fixture table. Thus, as many as 8 transducers can be filled simultaneously because the stations are independently operated. Each station consists of a transparent transfer tank, which is connected to both vacuum and oil fill lines by a pair of retractable hoses. Another hose is used to connect the bottom of the transfer tank to the filling port on the transducer. The valving is arranged so that the transducer and transfer tank combination can be evacuated, as the first step of the filling process. Then, the valves are adjusted so that oil is allowed to flow into the transducer, through the transparent transfer tank. This feature enables the operator to observe that no bubbles are in the oil as it passes from the transfer tank to the transducer and also shows that the transducer is full of oil when oil begins to accumulate in the transfer tank.

APPENDIX B

LIST OF FACILITIES, INSTRUMENTS, AND FIXTURES ASSOCIATED WITH TRANSDUCER RESTORATION AND REPAIR

1. FACILITIES, INSTRUMENTS, AND FIXTURES. Although not standardized, the following additional facilities, instruments, and fixtures for transducer restoration and repair are usually installed at the TRFs:

   a. Ovens for curing encapsulation materials (some ovens have vacuum capabilities)

   b. Controlled atmosphere assembly area

   c. Vapor/sand blast cleaning facility

   d. Cable vulcanizing facility

   e. Gas leak detection system

   f. Ceramic ring tester

   g. High potential tester

   h. Miscellaneous test jigs and fixtures, including boot stretchers

   i. Phasing/polarity test stand for 432-element and 48-stave transducers

   j. Machine shop, carpenter shop, and paint shop.

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